Segmentation of Medical Image Data-
Comparing deep learning models and how accurately they segment kidney scans

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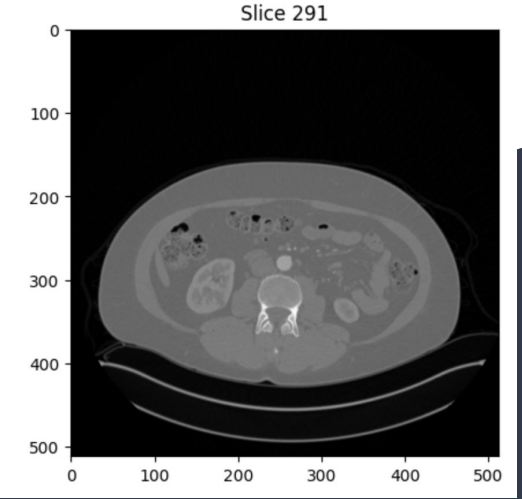

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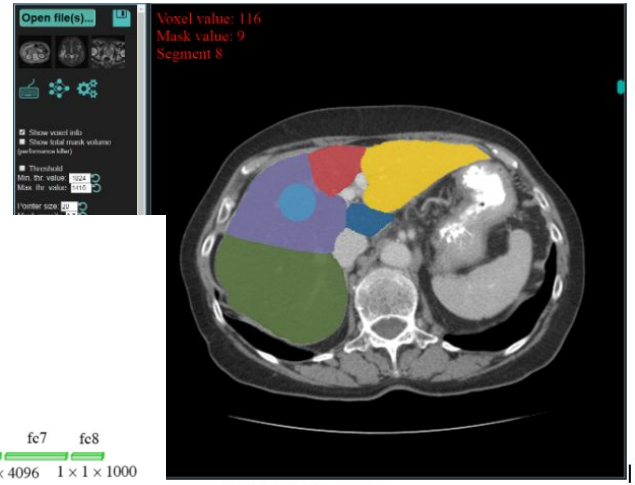
DS 4002, 4/21/2025

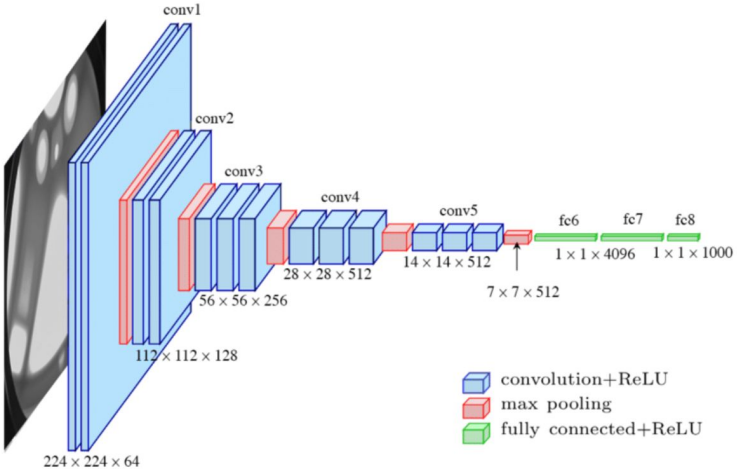
Background

Deep Learning, specifically CNNs, can enhance and automate medical imaging

Automating tumor segmentation alleviates physician burden and standardizes treatment



To learn more about the structural differences of DL models, will compare two CNN models' performance

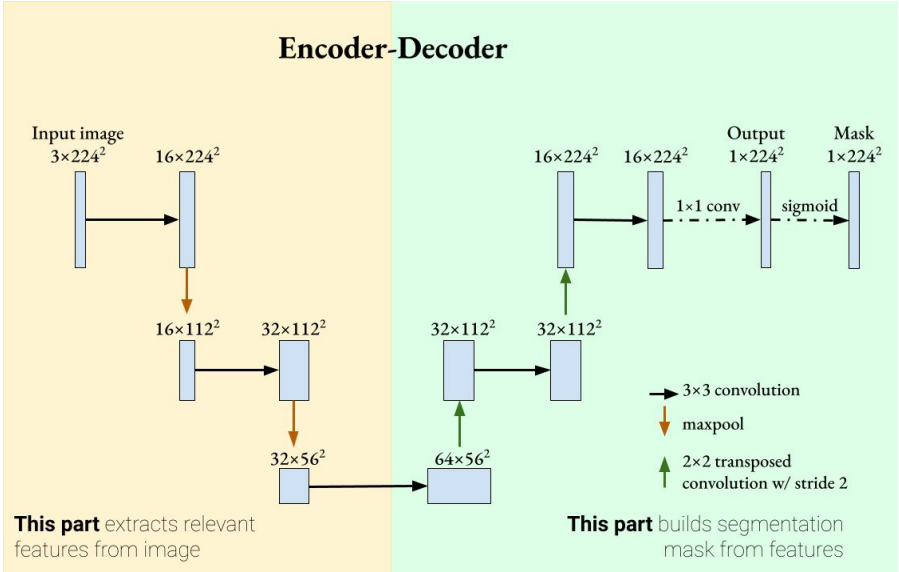


We predict that a more complex model will learn more effectively

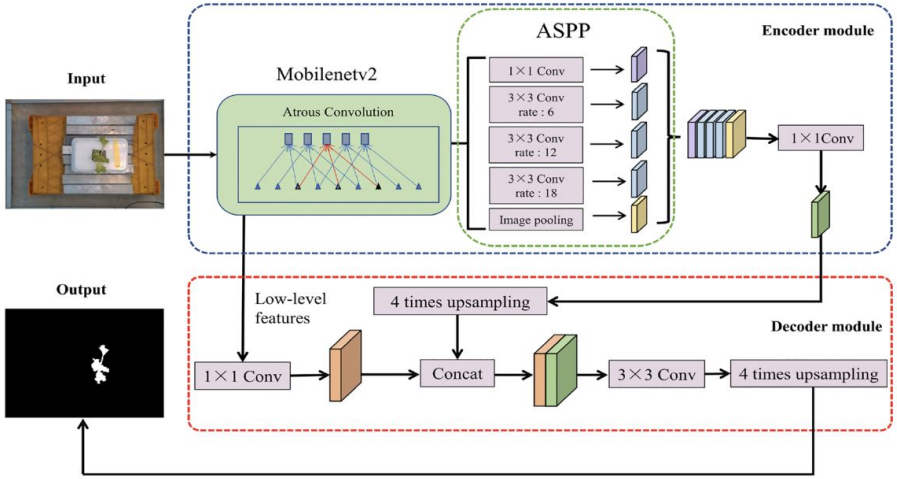
How well do different CNN UNet models perform kidney tumor and organ-at-risk segmentation?

Models

2-Layer UNet

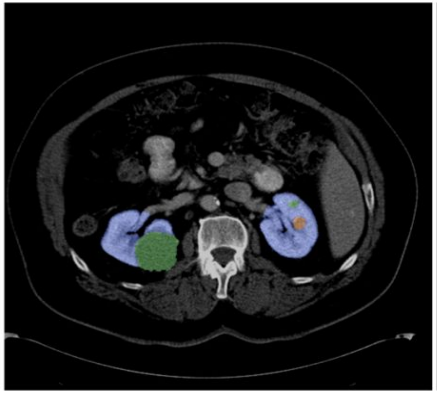


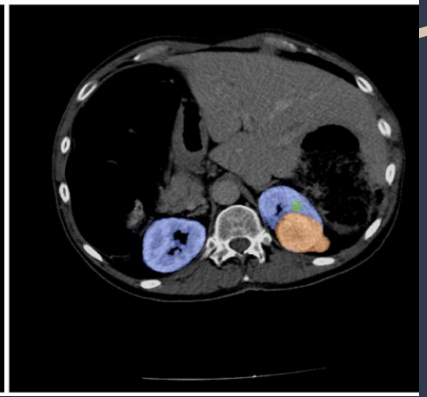
DeepLabV3+



Dataset

Field Name	Data Type	Description
case_#	folder	The patient # in the dataset
instances	folder	The manual contours made - follows a naming convention based on kidney or tumor, left or right kidney, and iteration #
segmentation	NIfTI	Ground truth segmentation mask
imaging	NIfTI	Patient CT scan
nii.gz	filetype	Neuroimaging Informatics Technology Initiative, used to store medical images (i.e., MRI, CT); stored as zip files in gz, unzipped with nibabel package in python

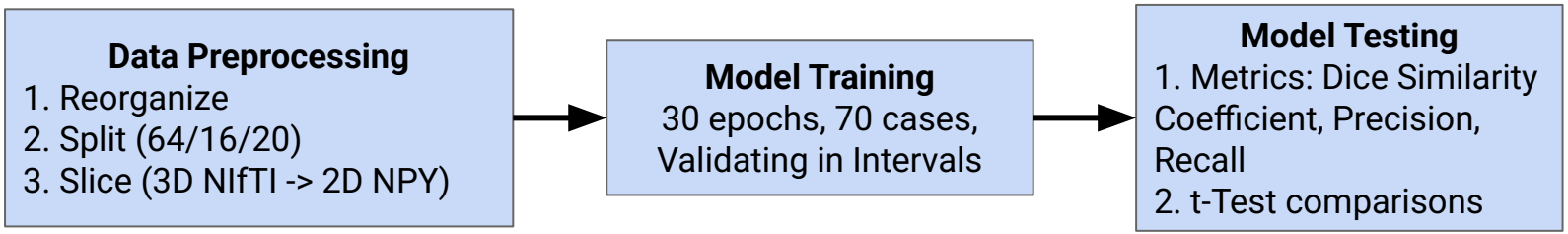




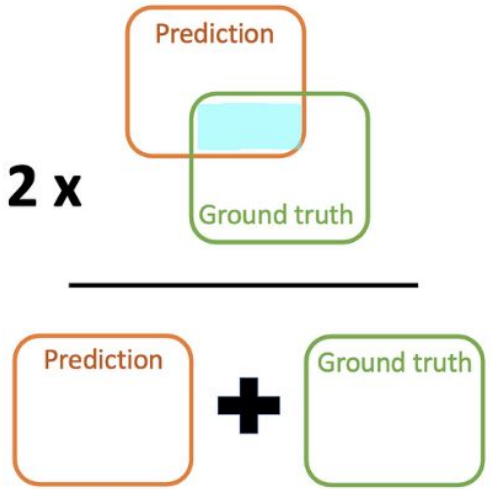
- CT scan and labels datasets from the 2023 Kidney & Kidney Tumor Segmentation Challenge
  - 590 cases, of which 110 cases are used
  - 492x396 resolution

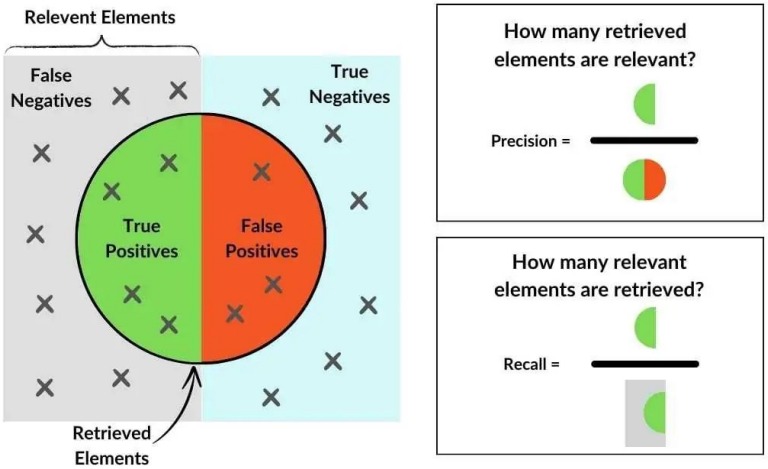
- Preprocessing: reorganized, split (64/16/20), and sliced (NIfTI -> NPY)

Analysis Plan



Metrics

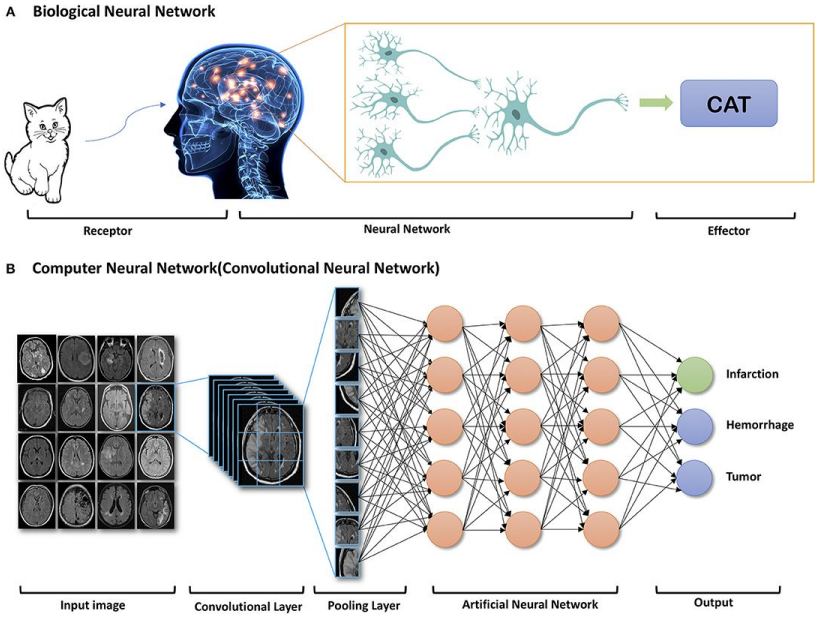

Prediction
2 x
Ground truth
Prediction
Ground truth


Relevent Elements
False Negatives
True Negatives
True Positives
False Positives
Retrieved Elements
How many retrieved elements are relevant?
Precision =
How many relevant elements are retrieved?
Recall =

Tricky Analysis Decision

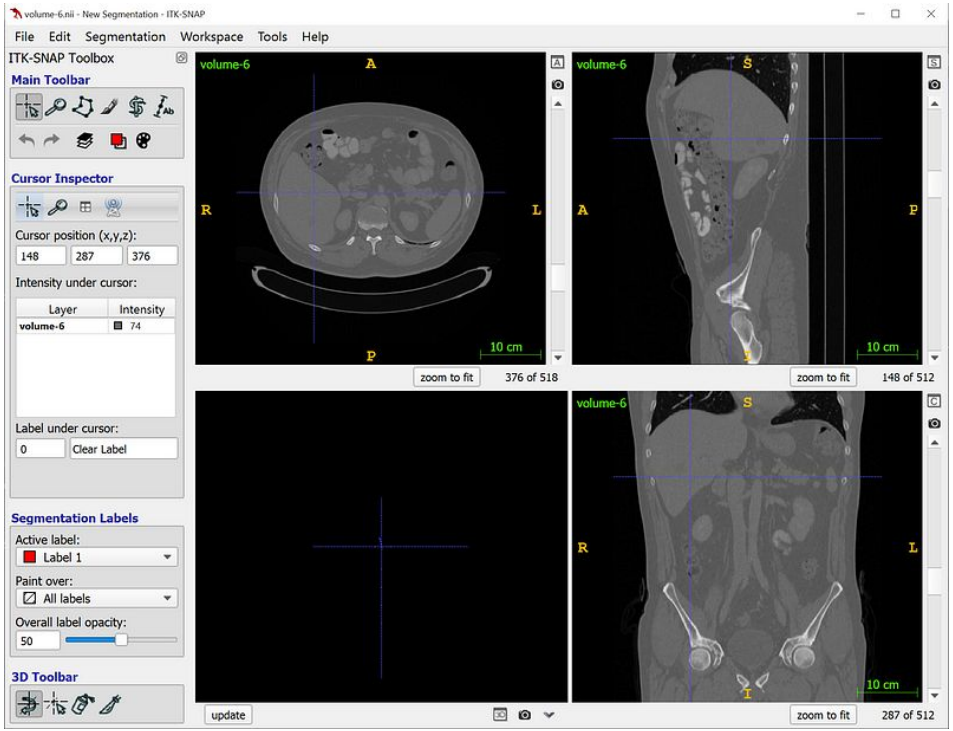
Selecting the best models to test

- There are many models and approaches that could be tested
- We chose two well-known models to analyze and compare that are also computationally inexpensive to train

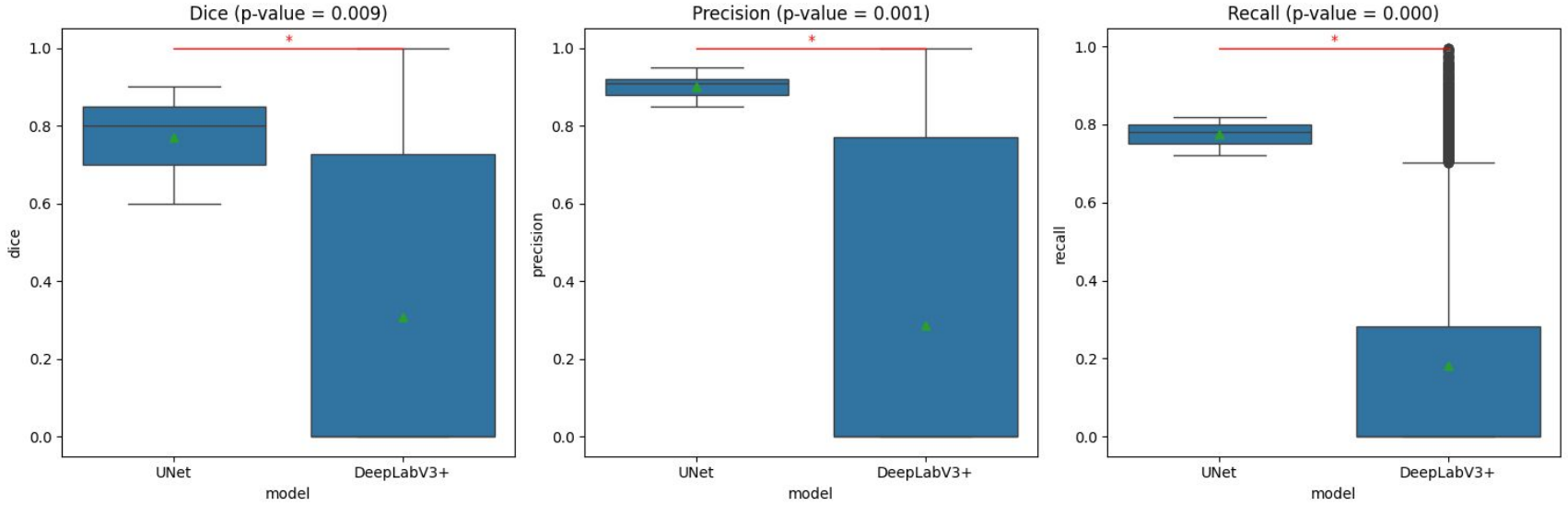


Bias and Uncertainty

- Issue: Difficulty working with large patient volumes and determining amount of data to use
- We decided to use an arbitrary amount of the dataset (110), but plan to use a larger amount for training in the future to improve the results
- We also chose to train the models slice-by-slice on Rivanna to reduce training time



Results and Conclusions



Next Steps

- Verify testing pipeline with field experts
- Run hyperparameter sweeps to optimize parameters
- Train models with more training data and more complex cancer segmentation tasks (i.e., cervical, prostate)

References

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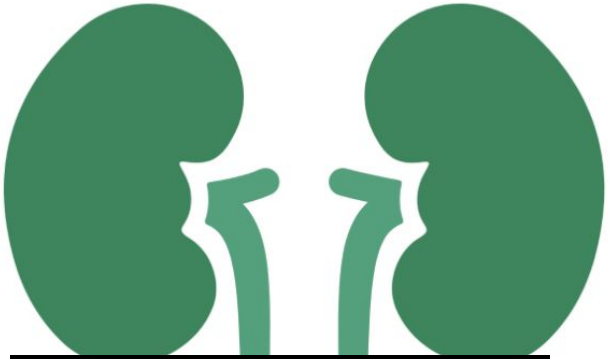
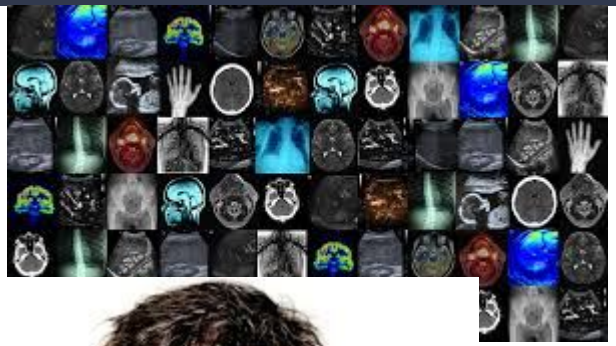
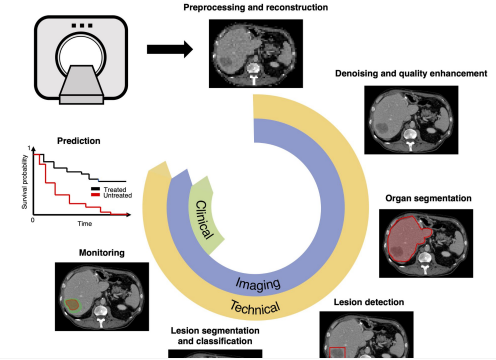
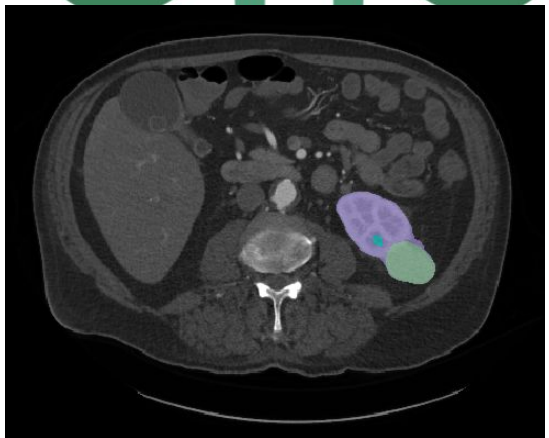
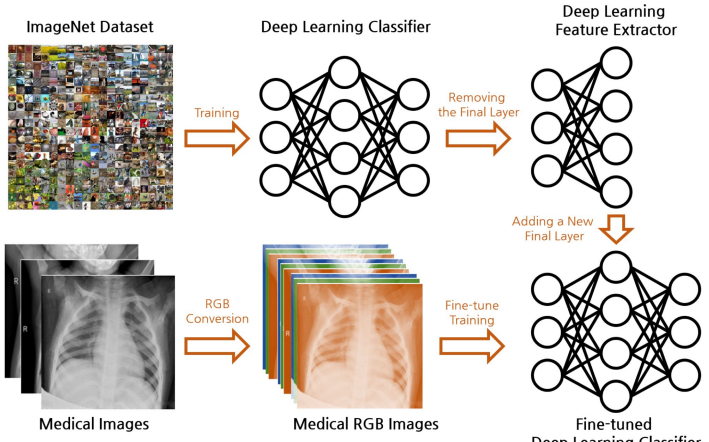
Thank You!






Preprocessing and reconstruction
Denoising and quality enhancement
Prediction
Survival probability
Time
Treated
Untreated
Organ segmentation
Clinical
Imaging
Technical
Monitoring
Lesion detection
Lesion segmentation and classification




ImageNet Dataset
Deep Learning Classifier
Deep Learning Feature Extractor
Training
Removing the Final Layer
Adding a New Final Layer
RGB Conversion
Fine-tune Training
Medical Images
Medical RGB Images
Fine-tuned